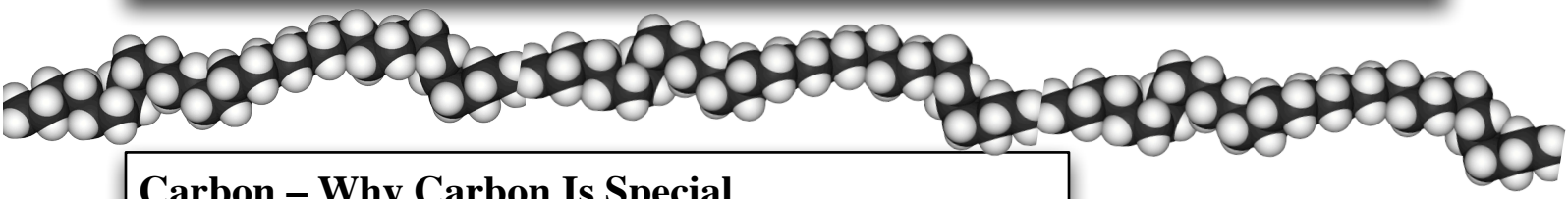

Carbon – Why Carbon Is Special

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There are now more than ten million organic compounds known by chemists. Many more undoubtedly exist in nature, and organic chemists are continually creating (synthesizing) new ones. Carbon is the only element that can form so many different compounds because each carbon atom can form four chemical bonds to other atoms, and because the carbon atom is just the right, small size to fit in comfortably as parts of very large molecules.

Having the atomic number 6, every carbon atom has a total of six electrons. Two are in a completed inner orbit, while the other four are valence electrons—outer electrons that are available for forming bonds with other atoms.

The carbon atom's four valence electrons can be shared by other atoms that have electrons to share, thus forming covalent (shared-electron) bonds. They can even be shared by other carbon atoms, which in turn can share electrons with other carbon atoms and so on, forming long strings of carbon atoms, bonded to each other like links in a chain. Silicon (Si), another element in group 14 of the periodic table, also has four valence electrons and can make large molecules called silicones, but its atoms are too large to fit together into as great a variety of molecules as carbon atoms can.

Carbon's ability to form long carbon-to-carbon chains is the first of five reasons that there can be so many different carbon compounds; a molecule that differs by even one atom is, of course, a molecule of a different compound. The second reason for carbon's astounding compound-forming ability is that carbon atoms can bind to each other not only in straight chains, but in complex branchings, like the branches of a tree. They can even join "head-to-tail" to make rings of carbon atoms. There is practically no limit to the number or complexity of the branches or the number of rings that can be attached to them, and hence no limit to the number of different molecules that can be formed.

The third reason is that carbon atoms can share not only a single electron with another atom to form a single bond, but it can also share two or three electrons, forming a double or triple bond. This makes for a huge number of possible bond combinations at different places, making a huge number of different possible molecules. And a molecule that differs by even one atom or one bond position is a molecule of a different compound.

The fourth reason is that the same collection of atoms and bonds, but in a different geometrical arrangement within the molecule, makes a molecule with a different shape and hence different properties. These different molecules are called isomers.

The fifth reason is that all of the electrons that are not being used to bond carbon atoms together into chains and rings can be used to form bonds with atoms of several other elements. The most common other element is hydrogen, which makes the family of compounds known as hydrocarbons. But nitrogen, oxygen, phosphorus, sulfur, halogens, and several other kinds of atoms can also be attached as part of an organic molecule. There is a huge number of ways in which they can be attached to the carbon-atom branches, and each variation makes a molecule of a different compound. It's just as if moving a Christmas tree ornament from one branch to another created a completely different tree.

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